Exploring the Planetary Science Achievable from a Balloon-Based Observatory Workshop,
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Japanese Balloon Telescope Program and Experiences

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Situation of Venus exploration in Japan

Akatsuki (orbiter)

- waiting for 5-6 years

Akastuki-2 (orbiter)

- discussion started
- competitive to MELOS (Mars) and others

Balloon telescope

- (2009. Jun), 2012. Aug, 2013 summer, ...

Ground-based telescope

- 1.6 reflector (Pirka telescope in Hokkaido Univ.)

Funding situation in JAXA seems very serious...

Balloon Project Members

Rikkyo Univ.
Prof. Makoto Taguchi, PI

Tohoku Univ. (Engineering)
Prof. Kazuya Yoshida
Asst. Prof. Yuji Sakamoto

ISAS/JAXA (Engineering)
Dr. Yasuhiro Shoji

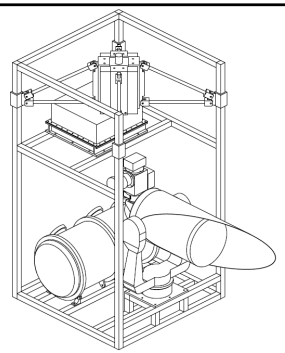
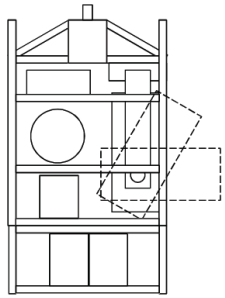
Hokkaido Univ. (Science and payload)
Prof. Yukihiro Takahashi
Asst. Prof. Makoto Watanabe

Project Overview

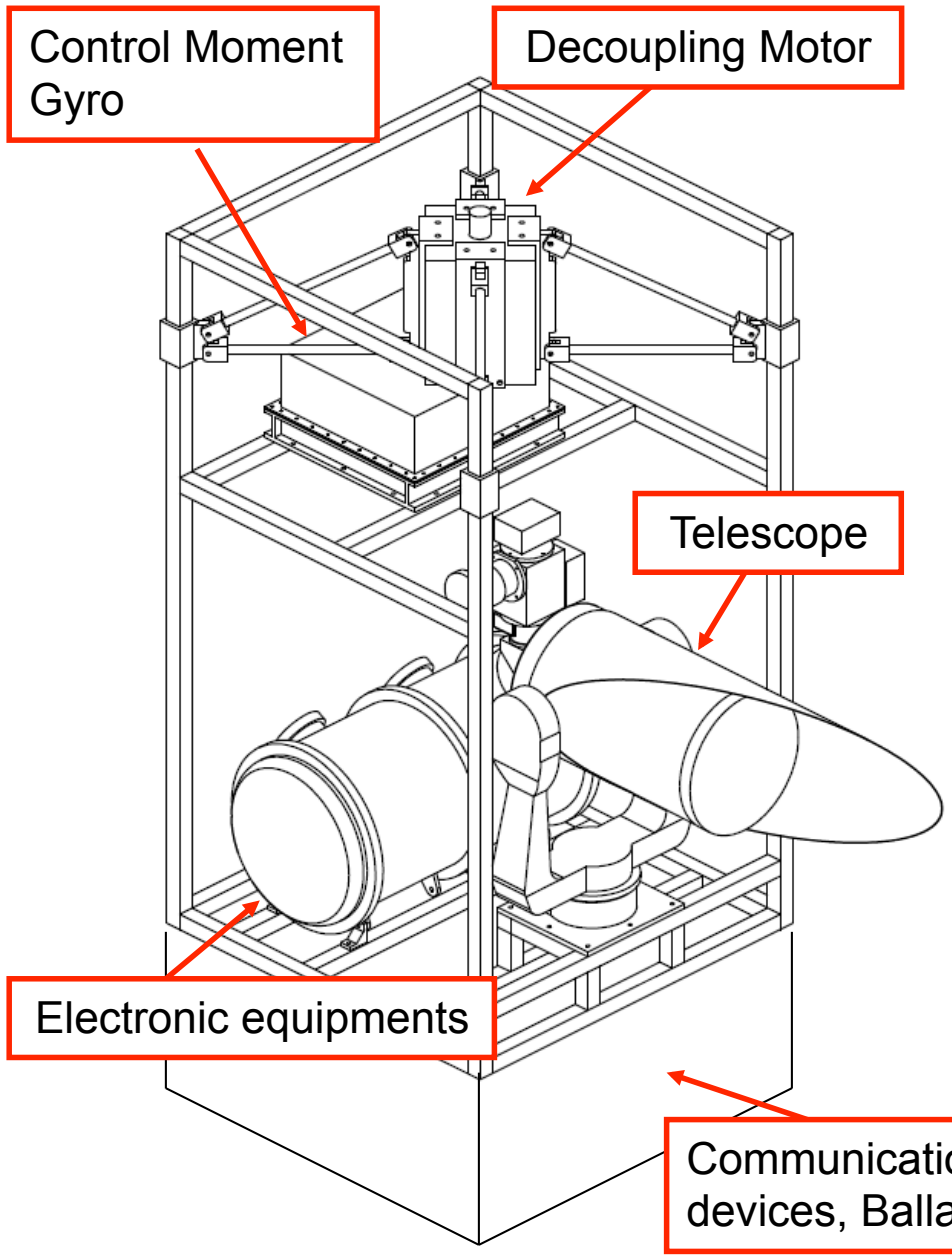
Project aim :

To develop the technology of BBT gondola for the high resolution imaging of planets(the observation system, the pointing control system, and the others), and to conduct technology demonstrations in Japan.

- To conduct the flight operation for continuous observations in the polar stratosphere.

	2009, Hokkaido, Japan	2012, Hokkaido, Japan	2013~2014, polar region (TBD)
Gondola Overview			
Telescope	Schmidt Cassegrain, 300mmφ		Cassegrain-Nasmyth, 400mmφ
Purpose	- Demonstration and verification of the optical system and the pointing control system.	-Demonstration and verification of the optical system and the pointing control system. -Basic data collection for “multi-target observation”.	-Continuous observation for about 24~48 hours. -Multi-target observation -Basic data collection for longer duration observation.

Gondola System (2012 Flight model)



Size : 1.0(W)×1.0(D)×2.5(H) m

Weight : Approx. 600 kg

Power System :

Solar Cell Panel

Li-ion Battery (25.9V, 50Ah)

Data Communication :

Downlink : 57600bps, telemetry data

Uplink : 1200bps, serial command

Data Storage :

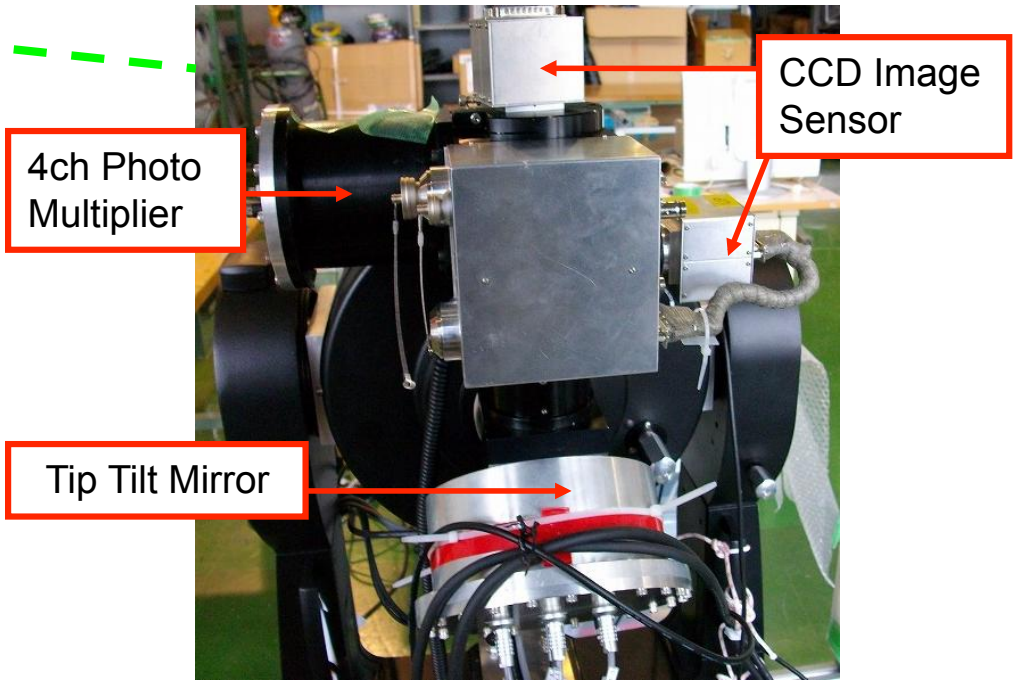
On board memories (SDHC cards)

Mission :

Telescope : Schmidt Cassegrain (300mmφ),

Observation camera : Digital CCD(x2) UV, NIR

Observation System



Telescope

Diameter of the Mirror : 300mmφ

Type : Schmidt Cassegrain

Focal Length : 6096mm (with a barlow lens)

Field of View : 158 x 122 arcec

Control : Direction (Az, El)

Image Sensor : Digital 10bit, 659(H)x494(V) pixels

Resolution : 0.2 arcsec (5.6×10^{-5} deg)

Wave Length : UV(300-450nm), NIR(750-1200 nm)

Data Storage : SDHC memory cards

Pointing Control System

Goal : To control telescope direction toward the target, and to pointing with

0.1 arcsec accuracy

The three stage pointing control system

First : Gondola Attitude Control

Attitude of the gondola (Azimuth direction) is controlled to point the solar cell panel toward the sun direction, and keep stable.

Second : Coarse Pointing Control

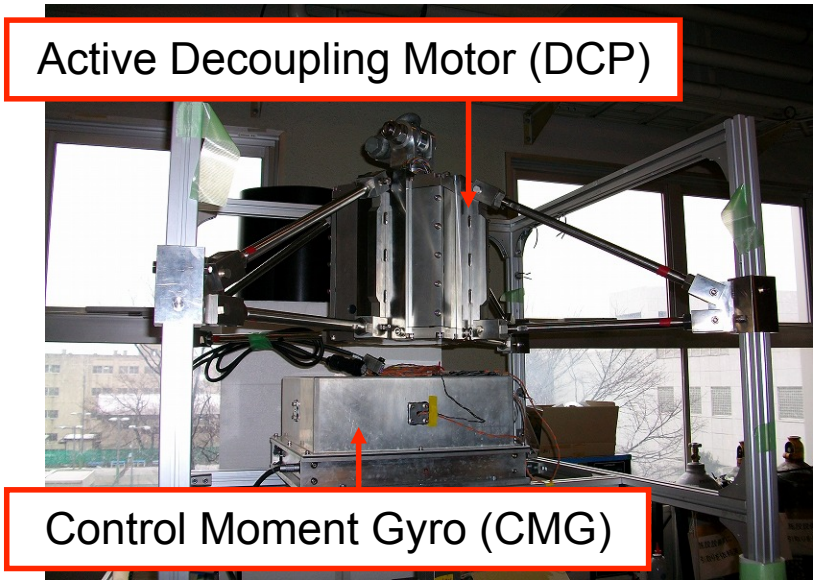
Azimuth and elevation angle of the telescope are controlled to enter the target in the filed of view and keep position of target on the center of the filed of view.

Third : Fine Pointing Control

Position of the target image is controlled with high accuracy during the exposure of the observation camera.

Pointing Control System

Gondola Attitude Control



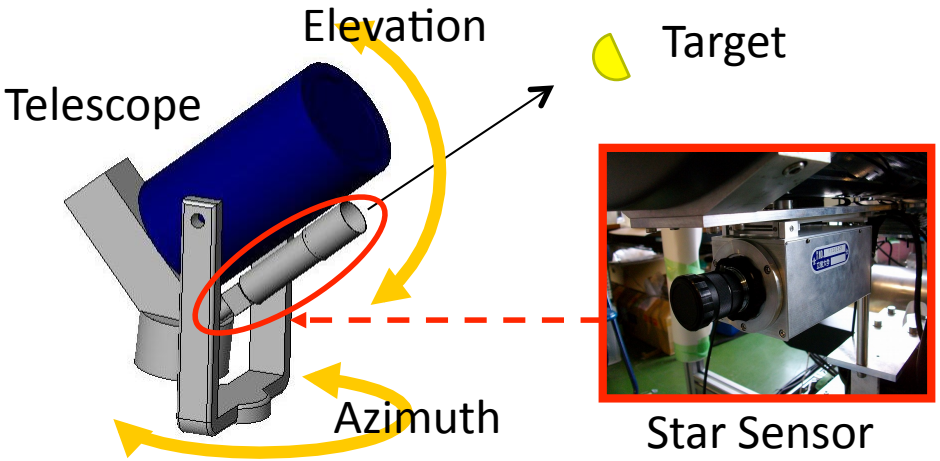
DCP twists the hanging rope and rotates the gondola.

CMG generates the torque to cancel the vibration.

Reference : 2 Sun Sensors（Digital CCD)
- Field of View : 69.8(H) x 55.2(V) deg
- Resolution : 0.11 deg

Required accuracy : < 1.4 deg

Coarse Pointing Control

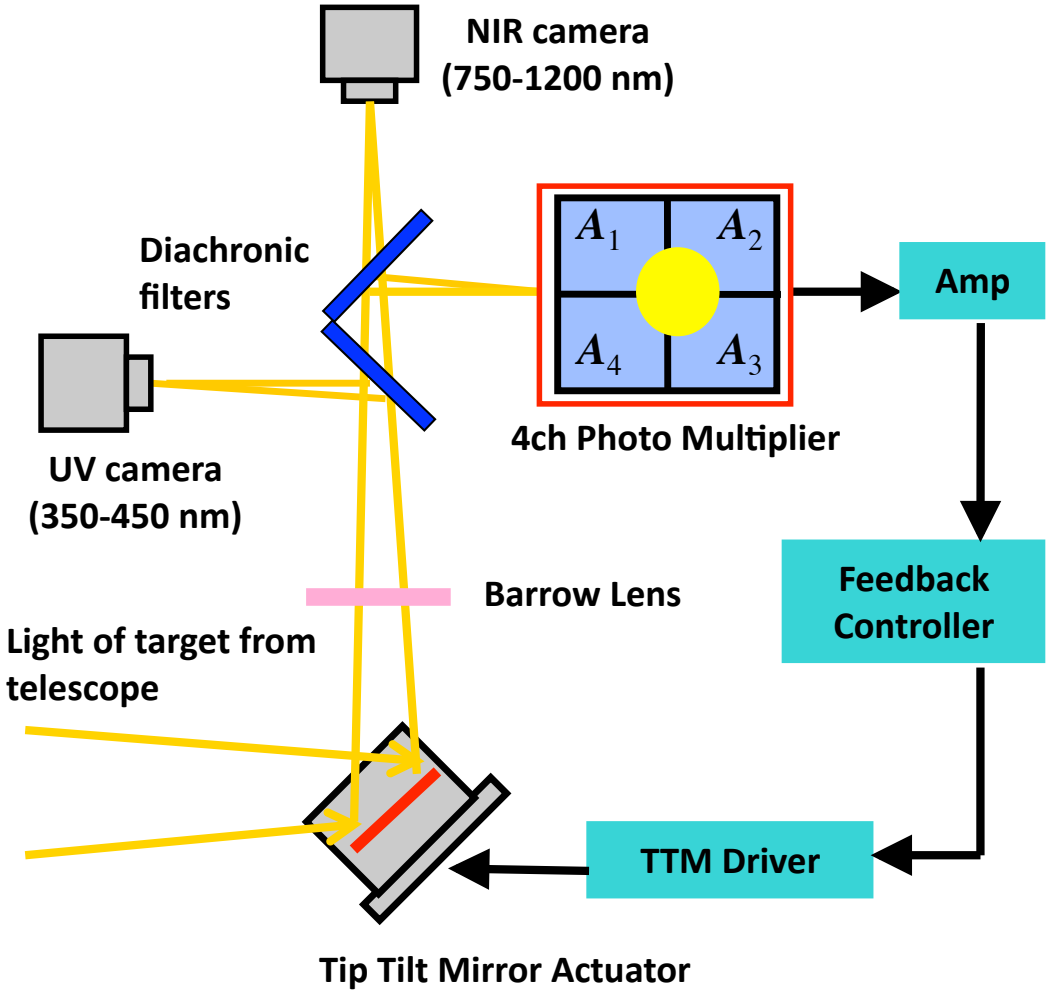


Telescope motor controls azimuth and elevation angle.

Reference : Target Star Sensor（Digital CCD)
- Field of View : 2.8(H) x 2.1(V) deg
- Resolution : 5.04 arcsec (0.0014 deg)

Required accuracy : < 61.2 arcsec (0.017 deg)

Pointing Control System



Overview of Fine Pointing Control system

Fine Pointing Control

Position of target image in FOV of mission cameras is detected and controlled in fine resolution.

Actuator : Tip Tilt Mirror (TTM)
- Piezo driven bi-axial actuator

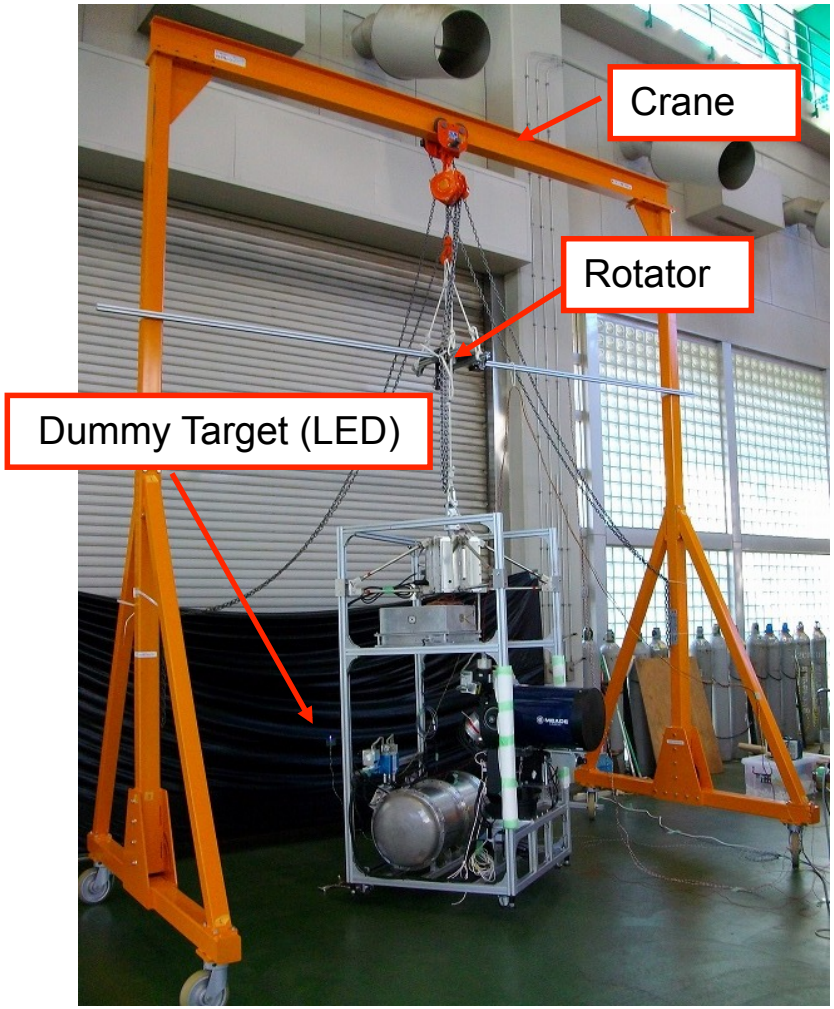
Reference : Photo Multiplier Tube (PMT)
- 4 photo multiplier tube are contained.
- Each cell outputs electric current by amount of the target light.

Feedback Controller :
Detect the position of the target from PMT outputs, Calculate the control output value to the TTM driver.
- Control Frequency : 1 kHz

Required accuracy : 0.1arcsec(2.8×10^{-5}deg)

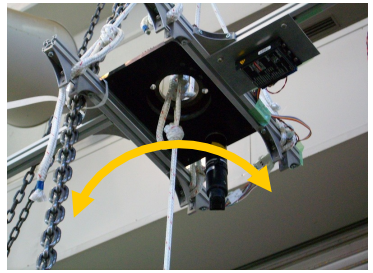
Ground Test of the Pointing Control System

Configuration to simulate the flight environment for ground test of unification of gondola attitude control and coarse pointing control



The gondola is hung from the crane with rope.

The rope can be rotated with arbitrary angular velocity or direction by a rotator to simulate the disturbance rotation under flight environment.

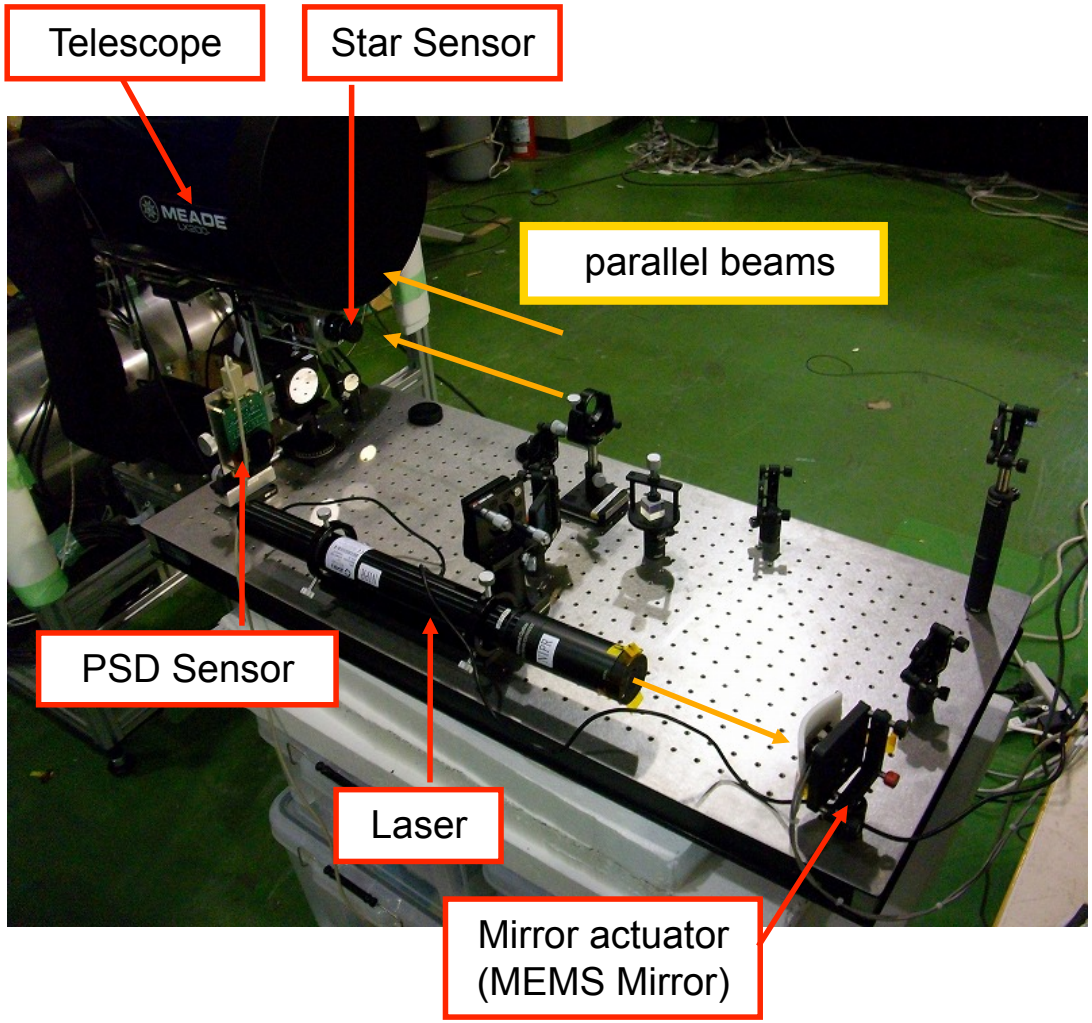


Some LEDs to simulate are attached on the black curtain as dummy light instead of real sun and target.

The performance of gondola attitude control and coarse pointing control is verified, and the control gain is tuned.

Ground Test of Pointing Control System

Overview of test bed for performance test of fine pointing control with vibration of target image as disturbances



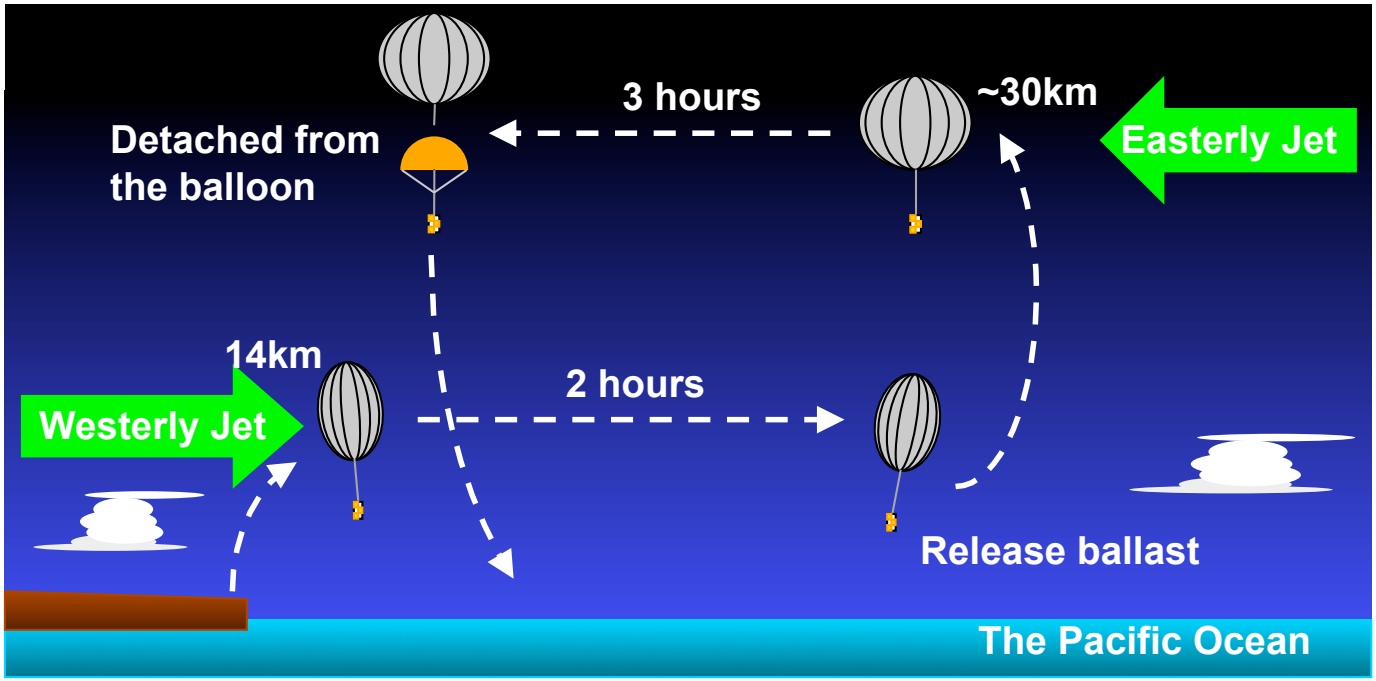
Two parallel beams are generated, and inserted into the telescope and star sensor.

The incident angle of the laser beams is varied with the range of approx. 20 arcsec with a biaxial gimbal mirror build by the MEMS technology.

Current angle of laser is detected by PSD sensor. Position of the light in FOV of telescope is controlled.

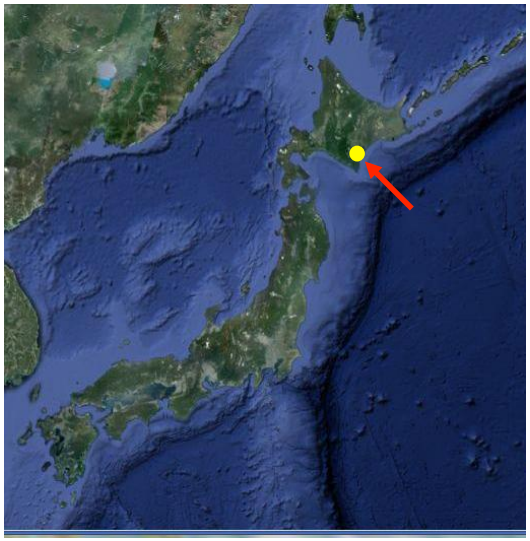
The performance of fine pointing control is checked, and the control gain is adjusted.

Flight Operation in Japan



Concept of the Boomerang Flight

Flight Operation in Japan



First Flight experiment : on June 3rd , 2009.

- Gondola Subsystems (power supply, house keeping data,) worked correctly, and some basic data are obtained.

-We couldn't conduct three stage pointing control operation and optical observation because of a trouble occurred on the onboard computer.

Second Flight experiment : Summer, 2012.

-Design of second flight model is based on first flight model, onboard computer is improved.

Taiki Aerospace Research Field (JAXA)

Possibility of payload contribution?

Akatsuki payloads

1 mu camera, 2 um camera, 10 mu camera
UV camera, Lightning/visible photometer

Budget problem

limited budget for Akatsuki team

Schedule overlapping

our launch at ESRANGE will be 2013 summer